such that there is no way they could establish communication after disaster. To handle such exceptional situations, cluster algorithms can supply additional vector information to each of the UEs. This vector can contain epicenter (or central location coordinates) that were computed by the cluster algorithms. The operator can bundle such applications as part of each phone to support disaster service applications. These applications can include search-and-rescue and lost-and-found applications and these applications may only be active during the disaster time. Such applications may be able to read the cluster vector and give local direction to user of that UE towards one of the cluster areas. This information may help isolated UEs to be part of some clusters.

[0053] For example, there may be four clusters: C1, C2, C3 and C4. The center of the cluster can be determined by drawing contour around all UEs that are part of that cluster. Then an approximate center location can be determined for each cluster: for C1 the centered location is X1 and Y1 coordinates; for C2 it is X2, Y2; for C3 it is X3, Y3; and for C4 it is X4, Y4. Such clustered vectors can be passed to UEs so that each UE could use that information and try to use disaster application that will navigate towards one of the nearest clusters. This information can be supplied to all UEs, but UEs that are isolated can use this information for local navigation when the UEs are unable to make any communication with other UEs.

[0054] Interference reported by UEs during D2D or with UE-to-BTS communication can be provided to the system. This information can be used to determine the size of cluster and the UE traffic density inside the cluster. If resizing or re-orientation is performed, for example across PLMNs and UE group, then the interference information can be used to properly size and/or orient the devices.

[0055] At 230, profiling end point communication and enhancing cluster knowledge and partitioning can be performed, as mentioned above. In this process, the system can first learn the communicating endpoints. This learning can involve various aspects. For example, the learning can involve learning how each of the UEs are engaged with other UEs in D2D communication or Wi-Fi direct communication. The learning can also involve receiving statistics from each of the UEs when they communicate using, for example, Wi-Fi direct. The learning can also include storing, for each UE, how, when, with whom, and where the UE is engaged in D2D communication. The learning can also involve learning if UEs are engaged in D2D communication with the help of two cell towers belonging to different operators. In such a case, exchange of the cluster information can be performed with respect to an inter-operator agreement.

[0056] The process of profiling end point communication and enhancing cluster knowledge and partitioning can also include handling inter-operator exchange of data. For example, if UE1 belongs to operator A and UE2 belongs to operator B, and these UEs happen to be in an overlapped coverage region, and in close proximity to each other, then cluster information can be shared as vectors via an inter-operator exchange mechanism.

[0057] The process can also include partitioning. For example, if a greater number of nodes than a predetermined threshold are present in the cluster, then the cluster can be partitioned for effective communication even if the UEs are in close proximity. Partitioning can have various aspects.

[0058] For example, partitioning can involve partitioning to preserve D2D groups if available. For example, if UE1 is

communicating with UE2, but not with UE5 or UE6, then a cluster can be partitioned with the cluster size of 2. Thus, UE1 and UE2 can be in Cluster-1 and UE5 and UE6 can be in cluster-2.

[0059] In another aspect, partitioning can be configured to preserve static subscriber profiles. For example, if UE1, UE2, and UE3 are part of a single family, living in a same residence, or the like, they can be maintained in a same cluster, regardless of other factors. It is possible that devices can be assigned to more than one cluster. For example, a device may be configured to a first cluster based solely on proximity and the device may also be configured to a second cluster based on the static subscription profile.

[0060] In a further aspect, the partition can be configured to preserve other supplementary profiles, if made available to the operators or system. Such supplementary profiles may include things like "friends" lists, contact lists of the user, or frequently called numbers associated with the user.

[0061] The process of profiling end point communication and enhancing cluster knowledge and partitioning can also include adaptive learning of D2D behavior. For example, when two or more nodes are directly exchanging data, the system can ask for statistics via control information about the nodes' interference, frequency used, Wi-Fi direct or LTE usage, available bandwidth, velocity of movement during the session, and the like.

[0062] The system can then use the learned behavior as cluster node characteristics. Thus, cluster group formation can be based on the learned behavior of the nodes.

[0063] As mentioned above, exchange of messages can be one aspect of certain embodiments. FIG. 3 illustrates an exchange of cluster messages according to certain embodiments. More particularly, FIG. 3 shows cluster message exchange that may occur during normal operation, namely prior to a disaster occurring.

[0064] FIG. 3 describes the sequence of operations that are performed in wireless access networks. The previous discussion described how a cluster is created, partitioned, resized, combined when needed, and also re-organized when a UE moves away from a group of cluster nodes. FIG. 3 gives a portion of messaging for the purposes of illustration. As shown in FIG. 3, there can be UE-1 to UE-4 and there can be many UEs, namely N UEs. Although not visible in FIG. 3, these UEs can be scattered in a given physical area. FIG. 3 illustrates a clustering processing with respect to one cell. The same approach can be applied across cells in a coordinated fashion within a single operator and also amongst various operators. In certain embodiments, the cluster processing can be performed by a disaster management function, which can reside either in a local cell, within an operator network, or apart from but connected to the operator networks. In certain embodiments, this disaster management function can be embodied by a cluster processing server (CPS).

[0065] In FIG. 3, at 1, UE-1, UE2, UE3, UE4 and so on up to UE-N can generate a respective location update request via network attach. Then, at 2, each network attach message can be forwarded to a CPS and the CPS can start to determine the spatial location of each UE. Meanwhile, at 3, a network attach response can be generated to each UE from the wireless access network with the help of other network elements, such as a mobility management entity (MME), home subscriber server (HSS) and the like, which are not shown in the figure.

[0066] At 4, the CPS, upon receiving each network attach request message, can determine spatial coordinates of the